ARRANGEMENT OF AN INDUCTIVE COUPLER FOR POWER LINE COMMUNICATIONS

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application is claiming priority to U.S. Provisional Application No. 60/429,172, filed November 26, 2002.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to power line communications (PLC), and more particularly, to placement of an inductive coupler around a cable having a shield or sheath of neutral conductors. The present invention is particularly advantageous in a case where the cable is an underground power line.

2. Description of the Related Art

In a power line communication system, a data signal may be coupled onto and off of a power line via an inductive coupler, such as described in US Patent 6,452,482. Inductive couplers may be placed around an uninsulated phase conductor or an insulated phase conductor. However, in underground power distribution systems, there is often no physical access to, or space around, a section of a phase conductor or a center conductor in the vicinity of a cable termination. Even when such access exists, work rules may require de-energizing the cable prior to attachment of the coupler. This process is inconvenient and requires personnel at both ends of a cable segment, and may sometimes affect service to power customers.

Many underground cables are built with a solid coaxial shield, grounded at each end, the main purpose of which is to provide shielding. Other underground cables are built with a plurality of wires wound spirally around an insulated core, where the plurality of wires serve as a neutral conductor. This shield or neutral conductor sheath is terminated just short of the end of a center conductor. The length of the unsheathed center conductor can be very short, often too short to allow installation of an inductive coupler.

In contrast, a shielded or sheathed cable segment located slightly away from the cable termination is generally available for coupler attachment while the cable is energized. However, efficiency of inductive coupling is reduced by the cable's shield or sheath. This is due to signal current induced in the shield or sheath, of magnitude similar to that in the center conductor, but of opposite phase. Since an output of the inductive coupler is proportional to a phasor sum of current passing through an aperture of the coupler, signal currents in the center conductor and shield or sheath conductors will tend to cancel, greatly reducing amplitude of a coupled signal.

SUMMARY OF THE INVENTION

An embodiment of the present invention is a placement of an inductive coupler around a sheathed or shielded coaxial power cable. The placement includes routing a wire that terminates the sheath or shield as a third conductor through an aperture of the coupler.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a diagram of an arrangement of an inductive coupler around a coaxial power cable.

Fig. 2 is a schematic diagram of a circuit for the arrangement of Fig. 1.

Fig. 3 is a diagram of an alternative arrangement of an inductive coupler around a coaxial power cable.

DESCRIPTION OF THE INVENTION

In a coaxial cable having a center conductor that carries a signal current, a concentric shield (or sheath) serves as a return circuit, carrying a current of similar magnitude but opposite phase to the signal current. When such a cable is passed through a core of a an inductive coupler, magnetic fluxes generated by the two currents tend to cancel, greatly reducing a ratio of current in a secondary winding of the coupler to current in the cable's center conductor. Thus, placing an inductive coupler around a shielded coaxial cable provides poor coupling to signal currents carried in the central conductor.

Consider a wire that connects the shield to its termination as a "drain" wire, completing a circuit for noise signals or power current to electrical ground. Routing the drain wire back through the coupler passes the current in the shield through the coupler core twice, once in the shield in one direct and once through the drain wire in the opposite direction, and essentially cancels the effect of the shield current.

Fig. 1 is a diagram of an arrangement of an inductive coupler around a coaxial power cable. It shows an inductive coupler 100 having a magnetic core 105 having an aperture 110 and a secondary winding 115, connected to a communications device 120. A coaxial cable 125, which may be a power cable, has a center conductor 130, a core insulation 135, and a shield (or neutral conductor) 140. A lead, i.e., a drain wire 145, connects shield 140 to ground 146. In the embodiment shown in Fig. 1, cable 125 passes through aperture 110 from left to right, and drain wire 145 passes through inductive coupler 100 from right to left.

Ideally, a magnitude of signal current I_1 in center conductor 130 is equal to a magnitude of signal current I_2 in shield 140, which is, in turn, equal to a magnitude of signal current I_3 in drain wire 145. The net magnetomotive force in inductive coupler 100 due to coaxial cable 125 and drain wire 145 is I_1 minus I_2 plus I_3, which equals I_1. This has the effect of electrically "peeling back" shield 140 and providing coupling between the signal current in the center conductor, i.e., I_1, and signal current in secondary winding 115, as well as to communications device 120.

Should center conductor 130 be energized at kilovolt potentials, then a high voltage termination device with a stress cone should be placed at each terminus of coaxial cable 125. Fig. 1 does not show such a termination, as the termination does not affect the operation or placement of inductive coupler 100.

Fig. 2 is a schematic diagram of the arrangement of Fig. 1. Again, the sum of currents I_1, I_2 and I_3 through coaxial cable 125 and drain wire 145 is equal to current I_1 in central conductor 130.

Should drain wire 145 be passed multiple times through aperture 110, with current I_3 flowing in the direction indicated in Fig. 1, then the corresponding sum of currents, including multiples of I_3, would yield a signal current in the secondary winding 115 proportional to I_1.

Fig. 3 is a diagram identical to Fig. 1 except that I_3 in a lead, i.e., a drain wire 300, passes through aperture 110 in the same direction as I_2. With the magnitudes of I_1, I_2, and I_3 identical to each other, a net magnetomotive force in inductive coupler 100 for the arrangement of coaxial cable 125 and drain wire 300 shown in FIG. 3 is I_1 minus I_2 minus I_3, which equals minus I_1. Since inverted phase does not affect a data signal, this arrangement again "peels back" shield 140 to providing coupling between the signal current in the center conductor, i.e., I_1,

and signal current in secondary winding 115, as well as to communications device 120. By extension, winding drain wire 300 around core 105 more than one time also recovers signal current proportional to I_1 or multiples thereof.

The present invention also contemplates coupling a signal to a coaxial cable that is not a power cable. Also, central conductor 130 may be replaced by a plurality of conductors surrounded by any outer shield.

It should be understood that various alternatives and modifications of the present invention could be devised by those skilled in the art. Nevertheless, the present invention is intended to embrace all such alternatives, modifications and variances that fall within the scope of the appended claims.